

SOLID ROCKET PLANT

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TWENTY-THIRD MONTHLY PROGRESS REPORT ALGOL SOLID ROCKET MOTOR PROGRAM

Contract No. NAS 1-1330

Period Covered: April 1963

Report 0498-01M-23

15 May 1963

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AEROJET GENERAL CORPORATION

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ALGOL SOLID ROCKET MOTOR PROGRAM

Prepared by

AEROJET-GENERAL CORPORATION
SOLID ROCKET PLANT
Sacramento, California

Report 0498-01M-23

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Prepared for

National Aeronautics and Space Administration
Langley Research Center
Langley Field, Virginia

AEROJET-GENERAL CORPORATION
A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

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I. INTRODUCTION

This is the twenty-third monthly progress report to the National Aeronautics and Space Administration (NASA) under Contract No. NAS 1-1330. This report covers the fabrication, testing, and delivery of Algol solid-rocket motors for the Scout vehicle during April 1963. The program has undergone numerous redirections since it was initiated; a summary of the program history is as follows:

PROGRAM MILESTONES

<u>Date</u>	<u>Event</u>
June 1961	The Algol I phase of the program was established with the receipt of a Letter of Intent covering 17 Algol I motors: 16 motors for delivery and one motor for static firing.
November 1961	Direction was received for the development of a new motor (designated Algol IIA) and a reduction of the number of motors for the Algol I phase.
January 1962	An amendment to the contract reduced the number of Algol I motors to nine. The original Algol II phase consisted of (1) the design, development, and testing of 14 Algol IIA motors, 10 motors for delivery and four motors for static firings; (2) delivery of three Algol dual transporters; and (3) tooling for processing four motors per month.
February 1962	Contract negotiations were completed on the scope of work defined in January.
April 1962	Contract Change Notification (CCN) No. 1 for the fabrication and delivery of two borescopes was received.
June 1962	A follow-on contract was negotiated for the delivery of 13 additional Algol IIA motors.
November 1962	Direction was received to reduce the Algol IIA motor delivery rate from four to two units per month, extending the delivery schedule six months.

I, Introduction (cont.)

December 1962	Authority was received to rehabilitate the Algol IIA-3 chamber for an additional (fifth) static firing.
January 1963	Direction was received for the fifth static firing to be conducted as proposed with the Algol IIA-3 rehabilitated chamber.
April 1963	Contract Change Notification No. 3 was received. This CCN directed Aerojet to modify the igniter to include a 2000-gm main charge, and to qualify the modified igniter by testing two existing and four modified igniters. A modified igniter is also to be used in a sixth static firing.

The Algol I phase of the program was completed in May 1962.

The schedule for the Algol IIA program (Figure 1) shows a reduction in the delivery rate for Algol IIA motors from four to two units per month in compliance with the direction received in November 1962.

A seventh static firing has been scheduled for 15 May. Motor IIA-11 and the modified igniter with a 2000-gm main charge have been selected for this test.

II. SUMMARY

The sixth full-scale static firing was conducted on 24 April 1963 and all test objectives were achieved. This is the first test in which jet vanes were not used; therefore, it is not necessary to correct the ballistic data obtained for the axial impulse loss due to the jet vanes. The total delivered impulse of motor Algol IIA-18 was 4, 726, 314 lbf-sec; action time was 67.9 sec; specific impulse was 223.2 lbf-sec/lbm. The web burning time was 48.1 sec, and the web impulse was 4, 173, 352 lbf-sec.

As a result of the hangfire that occurred in the test of motor Algol IIA-3 (Rehab), an igniter-recovery program was conducted. The program consisted of the testing of both two existing igniters (1400-gm main charge) and four modified

II, Summary (cont.)

igniters in a simulated free-volume chamber. A modified igniter was also used in motor Algol IIA-18 during the sixth static firing. In addition to the igniter-recovery program, a study was made to determine if the wax coating left on the surface of the grain after removal of the core has any effect on ignition. In conjunction with this study, propellant samples were taken from the grain surfaces of motors Algol IIA-13 and IIA-19 and were photographed and chemically analyzed to determine wax-residue and ammonium-perchlorate (oxidizer) content.

The delivery of all motors and the processing of motors subsequent to motor Algol IIA-20 were suspended, pending results of the igniter-recovery program. Motor Algol IIA-13 has been sent to the Naval Ammunition Depot (NAD), Concord, California, for radiographic inspection. Algol IIA-19 will be shipped to NAD and IIA-20 is in final assembly. As requested by NASA, motors Algol IIA-21 through IIA-26 will be cast using wood cores with Styrofoam inserts to provide a grain configuration similar to those tested and flown to date.

Motor IIA-11 is being returned from Wallops Island, Virginia for use in the seventh static test. The objectives of this test are to determine the ignition characteristics of motors cast using wooden cores with wooden inserts, and to determine the integrity of the motor under static-test conditions. The motor was one of a dual shipment exposed to an unknown temperature environment (believed to be below the current +50° limit).

III. PROGRAM STATUS

A. DESIGN

The basic development phase of the program was completed with the fourth static firing. However, a hangfire occurred in this test (Algol IIA-3 Rehab) and by mutual agreement of NASA and Aerojet, the igniter was redesigned. The igniter main charge was increased from 1400 to 2000 gm of Alclo pellets, and the

III. A. Design (cont.)

igniter chamber was extended 10 in. to enable the increased loading. In addition, four 0.750-in. -dia ports, 90 degrees apart, were drilled in the nozzle end of the chamber; the ports are oriented so that each vents down a valley of the grain. Cross-sectional views of the modified igniters are shown in Figures 2 and 3.

An igniter-recovery program was conducted to qualify the modified igniter (2000-gm main charge). The program included two tests of the existing igniter (1400-gm main charge) and four tests of the modified igniter (2000-gm main charge) to obtain comparative performance data. The modified igniter was also used in motor IIA-18 for the sixth static firing.

In addition to the igniter recovery program, a study was made to determine if wax left on the grain surface after removal of the core could inhibit ignition of the grain. In conjunction with this study, samples were taken from the grain surface of two motors to determine both the wax content on the grain surface and whether a fuel-rich grain surface results from use of a hard core.

An exact determination of how motor ignition is affected by wax left on the surface of the grain was not possible because of the complexity of the actual ignition process. However, by assuming an idealized process based on the energy obtained from a 1400-gm main charge igniter through the first 0.075 sec after fireswitch (see Figure 4), it was determined that a wax thickness of 0.0016 in. or greater could prevent ignition.

Strips of propellant were removed from the bore surfaces of motors IIA-13 and -19 to determine how use of the hard core affects the oxidizer content of the propellant-grain surface. These samples, obtained on fore and aft portions of the grain surface, were photographed and then physically and chemically analyzed for wax-residue and ammonium-perchlorate content.

 III, A, Design (cont.)

The results of the analyses show that the wax is distributed randomly and in small patches whereas the ammonium-perchlorate particles are evenly distributed, and the quantitative analysis results agree with the propellant specification.

Using the motor chamber index hole as zero-degree reference, samples of bore-surface propellant were removed from the aft end of the grain bore in strips approximately 0.5-in. -wide and 6-in. -long. The strip was started 11 in. from the aft surface and terminated 5 in. from the aft surface. Forward samples were removed approximately 6 in. aft of the igniter sleeve. Two samples were taken at each position from motor IIA-13, and single samples were removed from motor IIA-19. All strips were dry-cut with a 0.5-in. -stirrup cutter. One-position samples only were removed from the forward end of the grain because of the difficulty in reaching this area.

The propellant strips from motors IIA-13 and IIA-19 were examined by ultraviolet fluorescence. Small specks were found at 90, 135, and 315 degrees on samples 6, 7, and 15 removed from motor IIA-13. Samples 8 and 10 had areas of approximately 0.25-in. -dia at 135 and 180 degrees. No wax was found on the samples from motor IIA-19.

The ammonium-perchlorate samples were burned in a peroxide bomb, acid-washed, and titrated with silver nitrate. The accuracy of this test is approximately 97%. Results of the tests expressed as % $\text{NH}_4 \text{ClO}_4$ are:

Aft Position, degrees	Sample No.	Motor IIA-13	Motor IIA-19
0	1	57	59
	2	53	
45	1	57	59
	2	59	
90	1	58	69
	2	56	
135	1	57	56
	2	57	
180	1	58	61
	2	57	
225	1	59	58
	2	60	

 III, A, Design (cont.)

<u>Aft</u> <u>Position, degrees</u>	<u>Sample No.</u>	<u>Motor IIA-13</u>	<u>Motor IIA-19</u>
270	1	54	60
	2	60	
315	1	59	58
	2	59	
 <u>Forward</u> <u>Position, degrees</u>			
180	1	59	52
	2	60	

Photographs of each sample taken at 1X, 10X, and 50X magnification are shown in Figures 5 and 6. Although this study revealed no major discrepancy that would affect ignitors, the investigation will be continued.

B. FABRICATION

The remaining 15 chambers in the follow-on order have been fabricated. Two of these will be used as manufacturing spares. Fourteen insulated chambers, including the rehabilitated Algol IIA-3 chamber, have been received. Since the insulation of the rehabilitated chamber for Algol IIA-3 (Rehab) is not included in the contract, available funds enable insulating only two of the remaining three chambers. The remaining five nozzles are being fabricated, and the first nozzle is scheduled for delivery the last week of May.

C. MOTOR PROCESSING AND SHIPPING

Processing of Algol IIA motors was changed by NASA directive, TWX 337-338 from S. T. Butler to C. H. Parr, dated 30 August 1962. This directive requires either a radiographic or borescopic inspection of all deliverable motors. Motors IIA-4 through -9 were processed with Styrofoam star points imbedded in the grain. These inserts were originally used to change the configuration of the temporary wood cores. Because adequate release agents are unavailable, these inserts are not released from the propellant but remain in the motor. The

 III, C, Motor Processing and Shipping (cont.)

presence of the Styrofoam in the grain bore physically prevents the use of a borescope for inspecting the motor interior. After several attempts, the Styrofoam was mechanically removed from motors IIA-6 and -7. Motor IIA-7 was borescopically inspected in conjunction with the borescope training program conducted by Aerojet-General for NASA personnel.

Wooden, instead of Styrofoam, inserts were successfully used in motors IIA-10, -11, -12, and -13. An aluminum hard core was used in casting motors IIA-14 through -20. The following is a summary of the status of motors IIA-13 and IIA-16 through -20.

<u>Motor</u>	<u>Status</u>	<u>Grain Status</u>	<u>Inspection Status</u>
IIA-13	Shipped to NAD	Wood core, removed	To be radiographically inspected at NAD
IIA-16	To be delivered	Aluminum hard core, removed	Radiographically inspected at NAD
IIA-17	Delivered to PMR		Radiographically inspected at NAD
IIA-18	To be statically tested		Radiographically inspected at NAD
IIA-19	To be delivered		To be radiographically inspected at NAD
IIA-20	In final assembly		To be radiographically inspected at NAD

D. TOOLING

The tooling schedule is shown in Figure 7. Two sets of chocks for storage of Algot IIA motors were fabricated during the report period. Per NASA directive, the soft cores with Styrofoam fillets are being readied for use.

IV. TESTING

A. ALGOL IIA-18

1. Objectives

Algol IIA-18 was successfully fired 24 April 1963 at Sacramento. Minor objectives of the test designated AS-DA-08S-TH, were to:

- a. Qualify the modified igniter containing an increased main charge.
- b. Determine ignitibility of propellant cast with the aluminum hard core, using the modified igniter.
- c. Obtain pure ballistic data during the test of an Algol IIA motor.
- d. Confirm ballistic performance for an Algol IIA motor conditioned to +50°F.

All test objectives were achieved.

2. Motor Ballistic Performance

The pressure- and thrust-vs-time curves for this firing are presented in Figure 8. A summary of motor characteristics and performance data is given in Figure 9.

The overall motor ignition time was reduced from that of the previous motor tested, motor IIA-3 (Rehab). The ignition interval for motor IIA-18 was 100 millisecc compared to the 3.7-sec hangfire of motor IIA-3 (Rehab). The ignition transient curve is shown in Figure 10. Peak chamber pressure was 605 psia 0.234 sec after fireswitch and decreased to 550 psia after 1.015 sec.

The total delivered impulse was 4,726,314 lbf-sec over an action time of 67.9 sec with a specific impulse of 223.2 lbf-sec/lbm. The web burning time was 48.1 sec, and the web impulse was 4,185,163 lbf-sec. These values

IV, A, Algol IIA-18 (cont.)

are consistent with those previously reported and substantiate the conservative impulse data in reports of previous motor firings. In these reports, a correction was made for the drag imposed by the actuation of the jet vanes.

The motor was conditioned to +50°F for five days prior to the firing and was removed from the conditioning cell on the morning of the test. Because it was originally intended for delivery, no thermocouples were installed in the grain of this motor, and grain temperature was not monitored after the motor was removed from the conditioning cell. However, the temperature differential was insufficient to have caused a significant change in the grain temperature (from the conditioning temperature.)

3. Motor Components

All motor components of motor IIA-18 were of the flight configuration and performed satisfactorily. The nozzle (SN 633058) was the second to be statically tested from the second-source vendor, Cincinnati Testing Laboratories. The igniter (SN 54-31) was the first of the modified configuration to be used in a full-scale test.

a. Nozzle

Postfiring inspection of the nozzle showed that exit-cone erosion was uniform and that the flow pattern had been similar to those of the previous five development tests. This nozzle will be sectioned to obtain char depths; these values, when compared with data obtained from previous firings, will show whether quenching immediately after tailoff significantly reduces charring of both the exit cone and the entrance cap portion of the nozzle.

Erosion of the graphite throat was uniform. The throat area showed an increase of only 4.13%, somewhat less than that which

IV. A. Algol IIA-18 (cont.)

occurred on other test motors. A circumferential crack, similar to those found in previous nozzles tested, was found 4 in. from the aft edge of the graphite throat insert. The crack was clean, indicating that cracking occurred during quenching. As in previous nozzles, the crack propagated from the point where the aft edge of the steel closure and asbestos overwrap ends. Erosion of the nozzle entrance section was similar to that of previous nozzles. Prefiring and postfiring weights of the nozzle were 435 and 383 lb, respectively.

b. Insulated Chamber

The chamber (SN 699041) used for the test was the same light-weight configuration as those of motors IIA-2, -3, -2 (Rehab), and -3 (Rehab). Postfiring examination revealed that the insulation maintained its integrity throughout the firing.

c. Igniter

The igniter used in this test was of the modified configuration with the increased main charge (2000 gm vs 1400 gm) and additional porting. Prefiring and postfiring weights were 30 and 14.2 lb, respectively. Although the ignition interval was similar to that of other acceptable firings, the data showed that motor IIA-18 reached full pressure much faster than did previous motors. The following tabulation compares ignition characteristics of motors of the final grain configuration that have been fired. Motor IIA-3 (Rehab) was not included in this tabulation because of the hangfire.

<u>Motor</u>	<u>Igniter Main Charges, gm</u>	<u>Core</u>	<u>Ignition Delay, millisecc</u>	<u>Peak Chamber Pressure, psia</u>	<u>Time to Peak, sec</u>	<u>Time to 495 psia (90% av Pc, sec)</u>
IIA-3	1400	Styrofoam Inserts	40	577	0.777	0.165
IIA-2 (Rehab)	1400	Styrofoam Inserts	55	613	0.825	0.132
IIA-18	2000	Aluminum Core	100	605	0.234	0.151

IV. A. Algol IIA-18 (cont.)

Ignition delay is defined as the time interval from the application of electrical contact to the time at which a tangent extended along the ascending portion of the chamber pressure trace intercepts the time scale.

B. IGNITERS

The igniter-recovery program included the testing of both two igniters with 1400-gm main charges and four modified igniters with 2000-gm main charges. These igniters were tested in an instrumented free-volume test chamber. Provisions were made to monitor ignition energy and chamber pressure at four stations along the chamber, 7.5, 12.5, 17.5 and 22.5 ft downstream of the igniter. Igniter pressure was monitored in the tests of the modified igniter, but was not monitored in the first two tests because the flight-design adapters used for these tests had only one pressure tap. Chamber pressure at each station was monitored with a Taber pressure transducer; ignition energy was monitored with a chromel-alumel thermocouple located in a gold button calorimeter. A tabulation of data from these tests is shown in Figures 11 through 17.

The inner diameter of the free-volume chamber is 15.25 in. and the length is 370.75 in., with a corresponding volume of 67,775 cu in. This chamber closely simulates the free volume of the Little Joe II motor (68,256 cu in.) and, although the free volume of the Algol IIA motor is only 41,800 cu in., it was selected because of its immediate availability. This difference in free volume should be considered when the calorimetry data are reviewed. Pressure-vs-time curves for a typical igniter of each configuration are shown in Figure 18 and 19.

V. FUTURE WORK

Processing of motors for delivery will be started again and motors IIA-21 through -26 will be cast, using wooden cores with Styrofoam inserts.

V. Future Work (cont.)

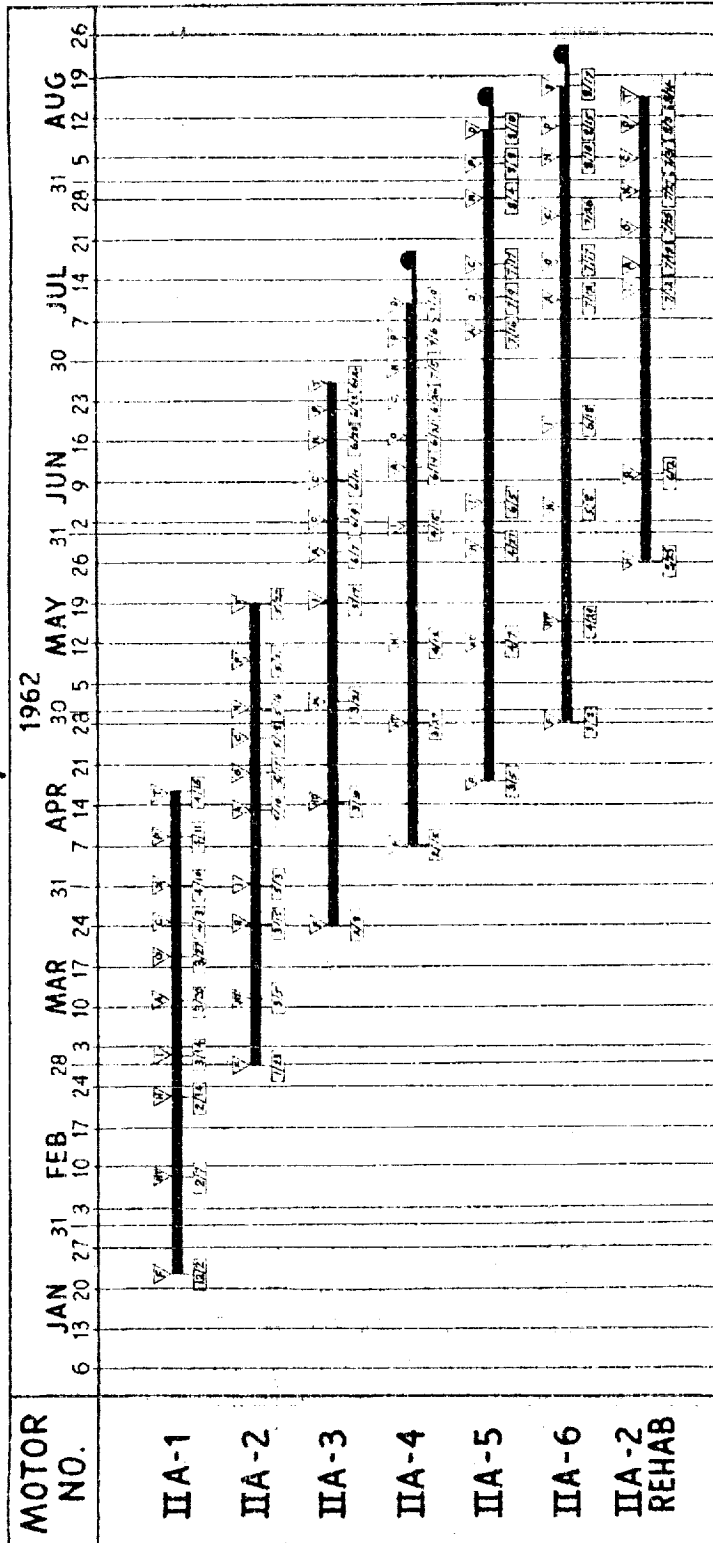
Algol IIZ-11 is scheduled to be statically fired at +50°F on or before 15 May 1963. This will be a straight ballistic firing with no jet vanes installed.

ALGOL II A

SCHEDULE REVISION "E" NOV 1962
LETTER CONTRACT RECEIVED 7 JUNE 1961

MOTOR PRODUCTION/DELIVERY SCHEDULE

NAS-1-1330

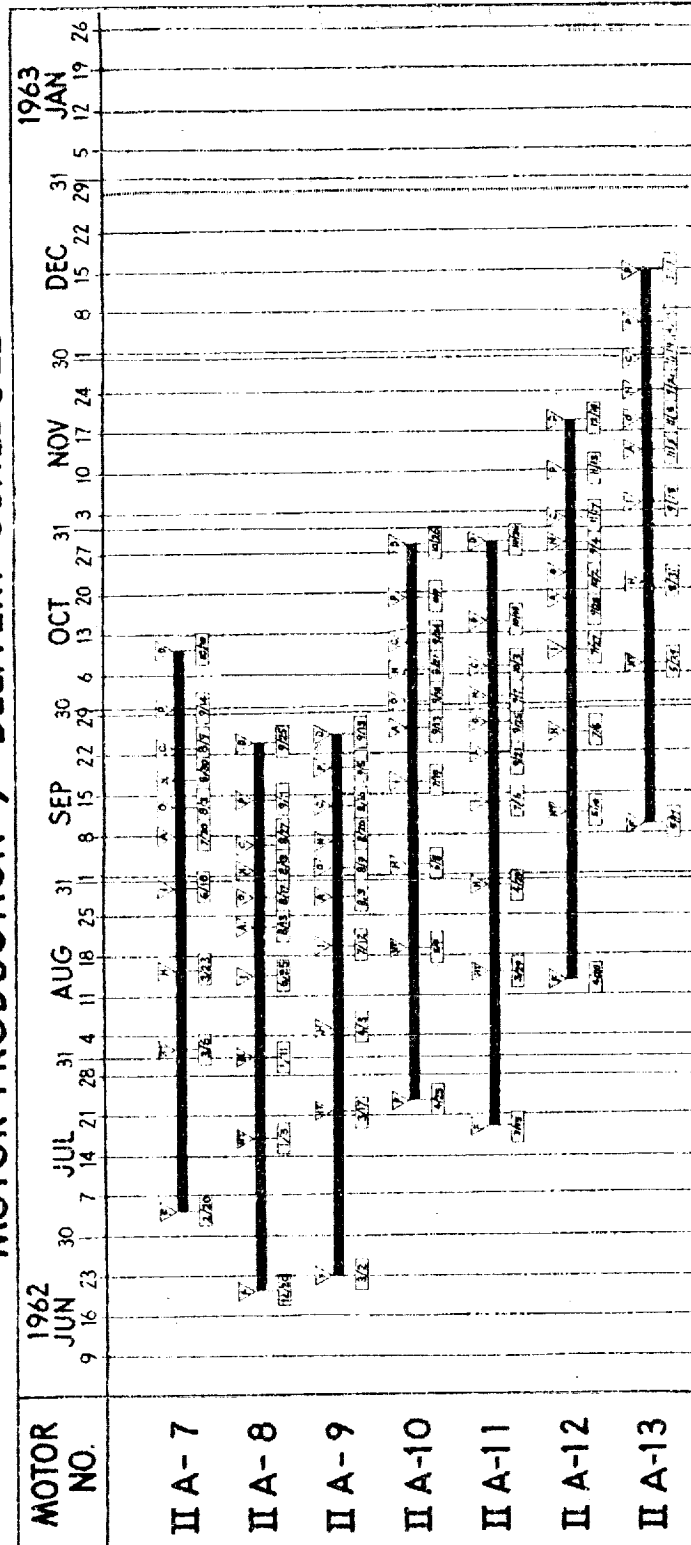


F START FABRICATION CHAMBER A RECEIVE, ABRASE AND LINE D FINAL INSPECTION AND SHIPMENT, F.O.B. NIMBUS, CALIF.
HT HEAT TREAT O CAST PROPELLANT T TEST FIRE (A.G.C. SACRAMENTO)
H HYDROTEST C CURE PROPELLANT S SCHEDULED TASK COMPLETION DATE
R REHABILITATE CHAMBER N RECEIVE NOZZLE A ACTUAL DATE TASK COMPLETED
I INSULATE CHAMBER P FINAL ASSEMBLY R REVIEW DATE - FLOWN(SUCCESS)



Figure 1, Sheet 1 of 4

ALGOL II A MOTOR PRODUCTION / DELIVERY SCHEDULE



F START FABRICATION CHAMBER
 HT HEAT TREAT
 H HYDROTEST
 R REHABILITATE CHAMBER
 I INSULATE CHAMBER
 A RECEIVE, ABRASE AND LINE
 O CAST PROPELLANT
 C CURE PROPELLANT
 N RECEIVE NOZZLE
 P FINAL ASSEMBLY
 D FINAL INSPECTION AND SHIPMENT, F.O.B. NIMBUS, CALIF.
 T TEST FIRE (A.G.C. SACRAMENTO)
 V SCHEDULED TASK COMPLETION DATE
 [] ACTUAL DATE TASK COMPLETED
 ---- REVIEW DATE



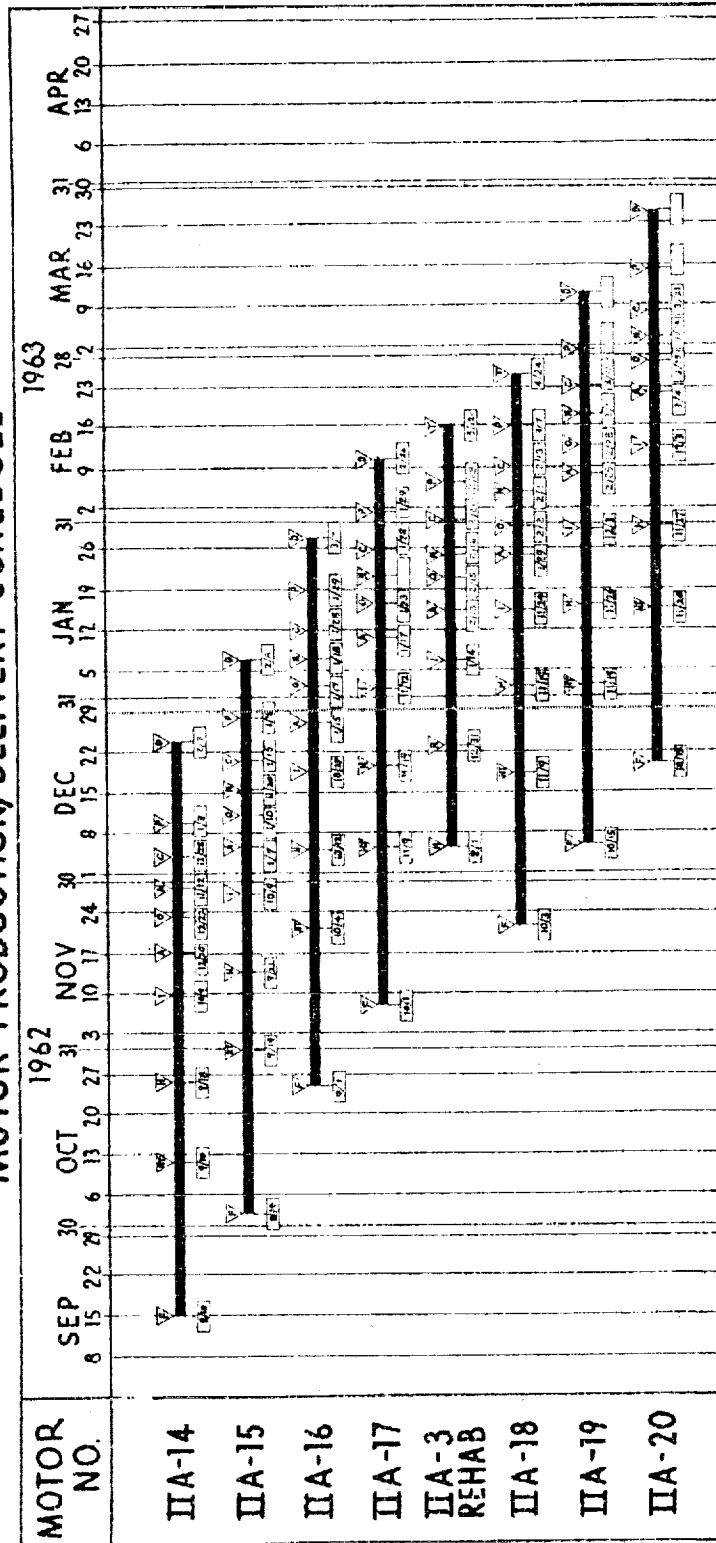
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Algol II Production and Delivery Schedule

Figure 1, Sheet 2 of 4

ALGOL II A

MOTOR PRODUCTION/DELIVERY SCHEDULE



F START FABRICATION CHAMBER
 HT HEAT TREAT
 H HYDROTEST
 R REHABILITATE CHAMBER
 I INSULATE CHAMBER
 A RECEIVE, ABRASE AND LINE
 O CAST PROPELLANT
 C CURE PROPELLANT
 N RECEIVE NOZZLE
 P FINAL ASSEMBLY
 D FINAL INSPECTION AND SHIPMENT, F.O.B. NIMBUS, CALIF.
 T TEST FIRE (AGC, SACRAMENTO)
 [] SCHEDULED TASK COMPLETION DATE
 [] ACTUAL DATE TASK COMPLETED
 --- REVIEW DATE

PAGE 3 OF 4

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Algol II Production and Delivery Schedule



Figure 1, Sheet 3 of 4

ALGOL II A

MOTOR PRODUCTION/DELIVERY SCHEDULE

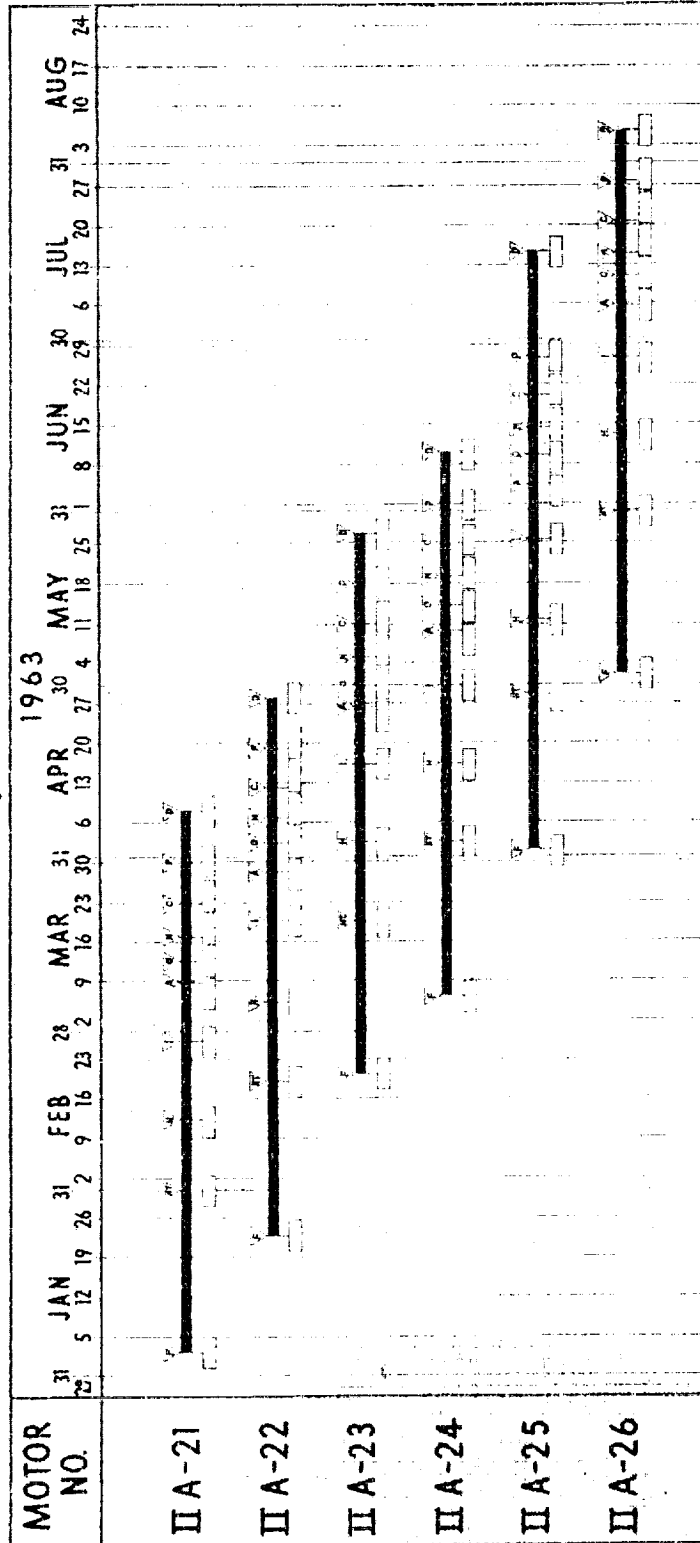
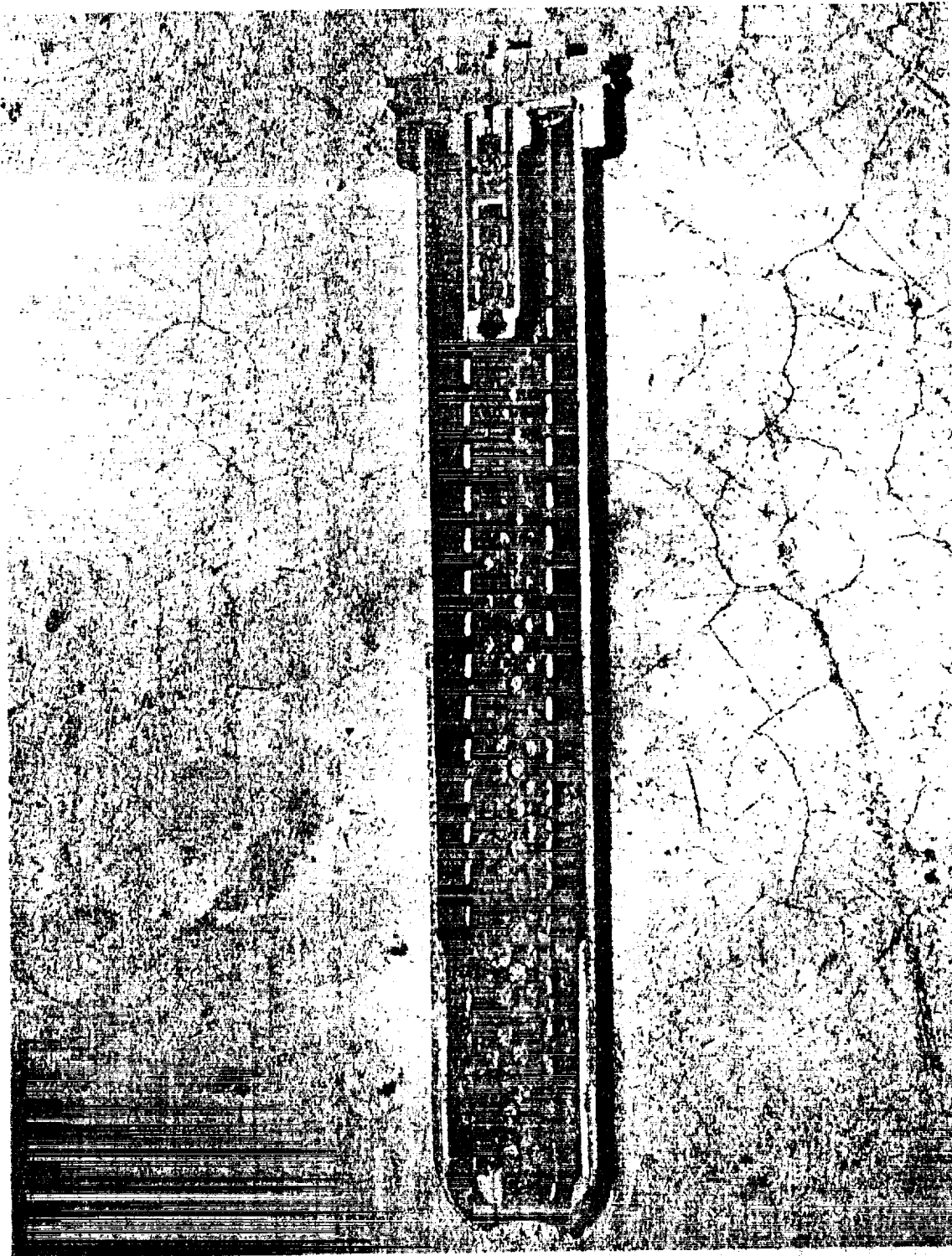


Figure 1, Sheet 4 of 4



Postfiring View of Ports on Modified Igniter (Photo 4-63S 07473)



Cross-Section View of Modified Igniter (Photo 5-63S 08100)

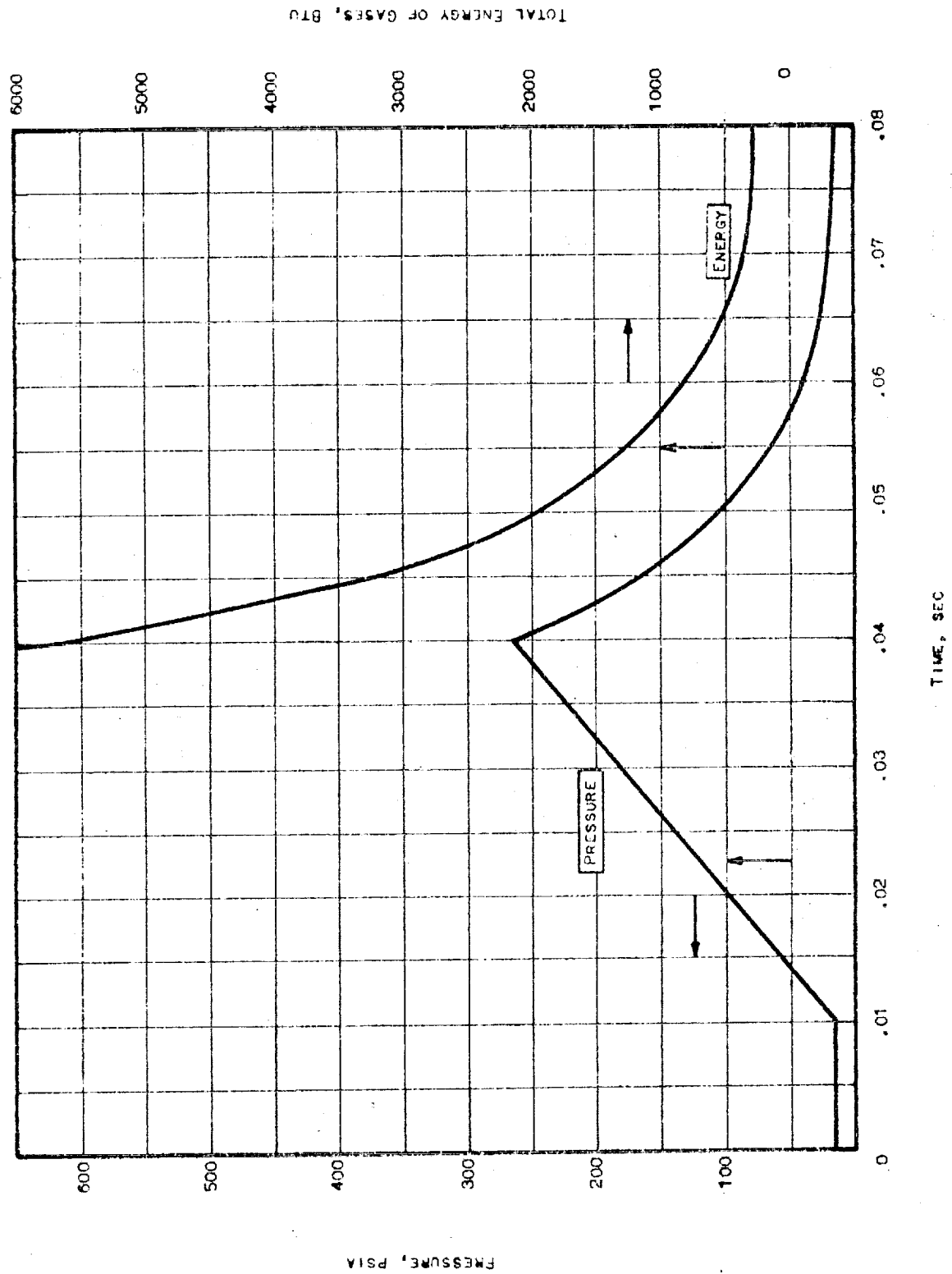
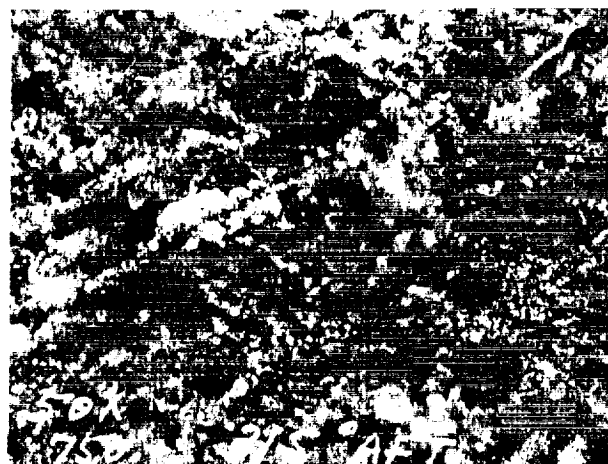
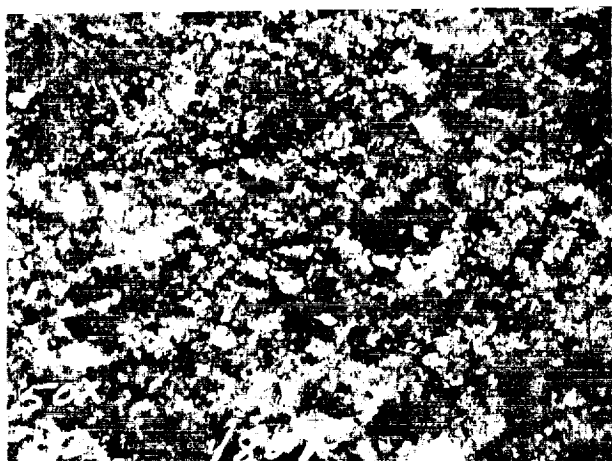
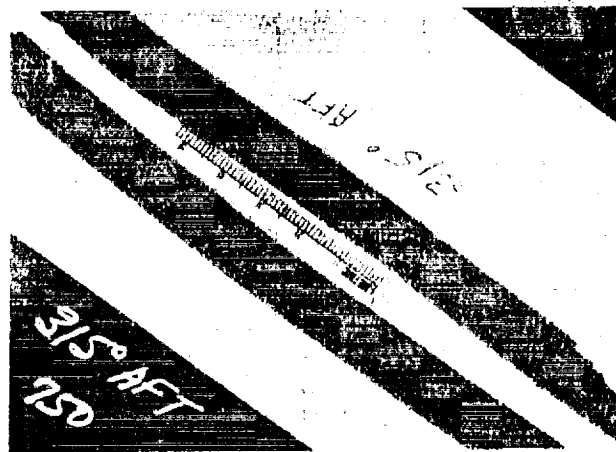
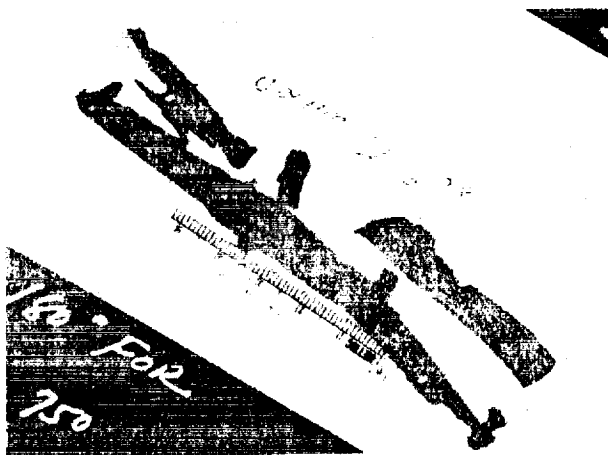
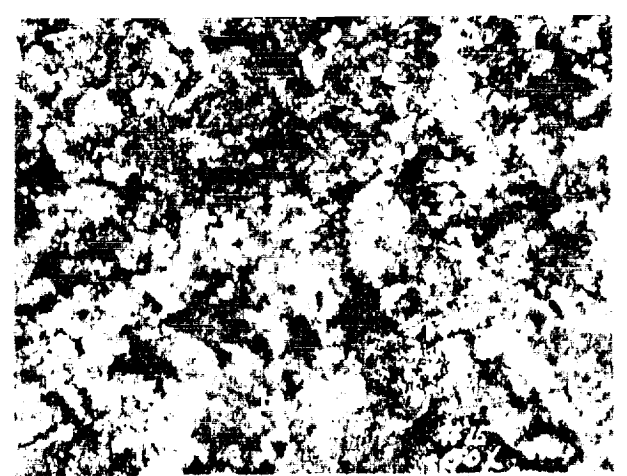
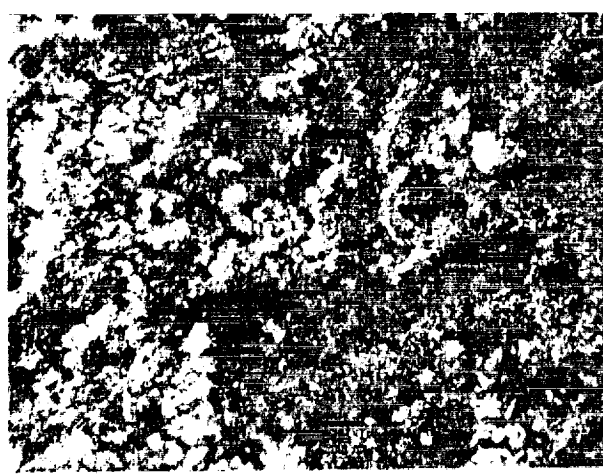
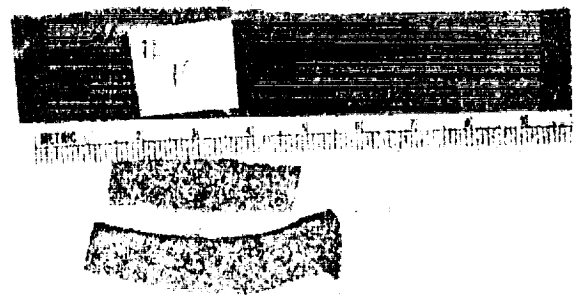
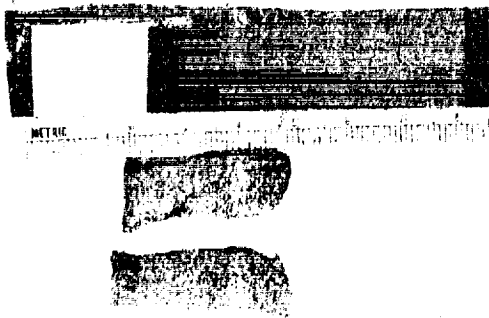


Figure 4

Pressure- and Energy-vs-Time Curves for: 1400-gm Main Charge Igniter



Propellant Samples From Motor IIA-13



Propellant Sample From Motor IIA-19

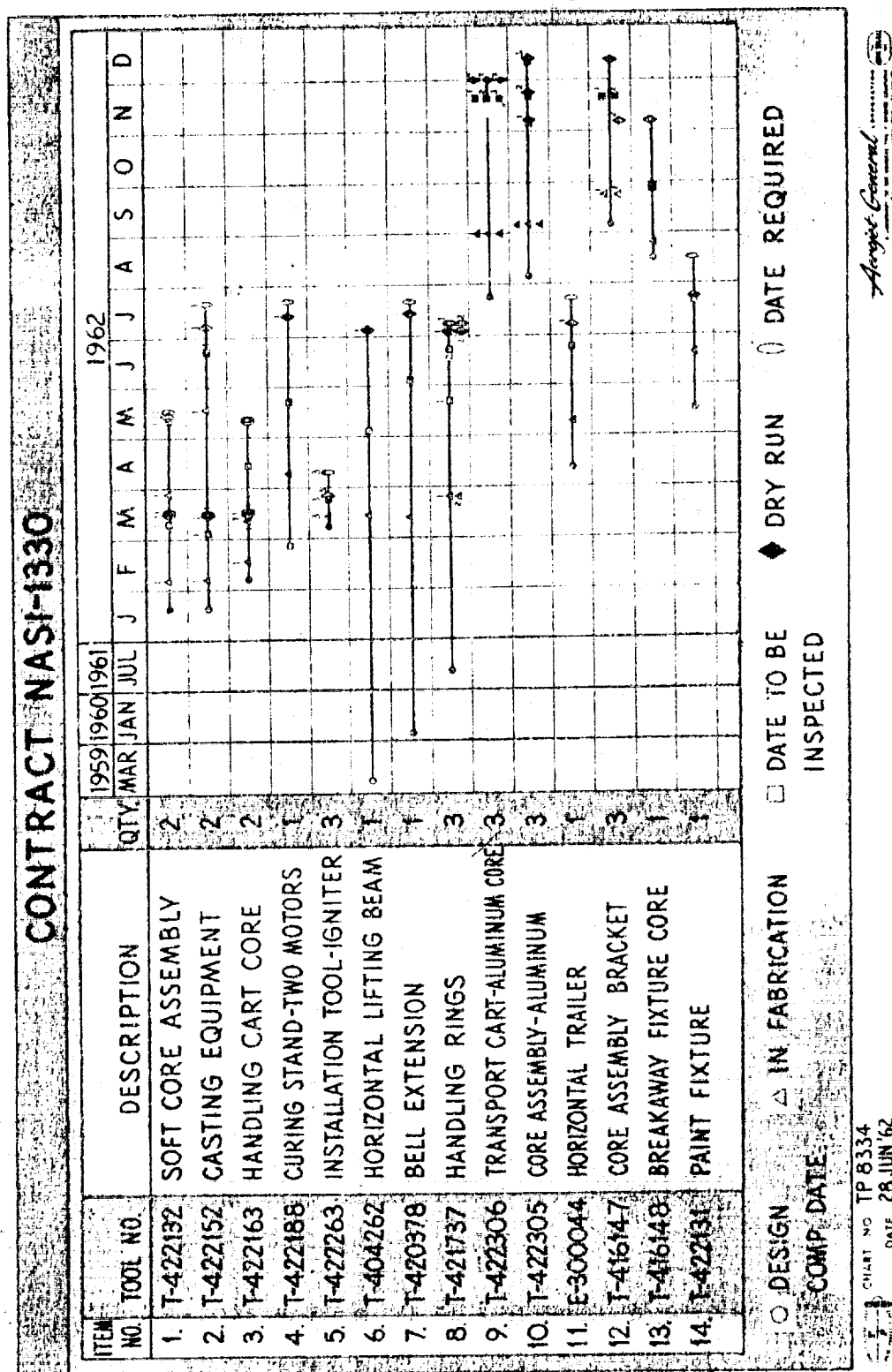
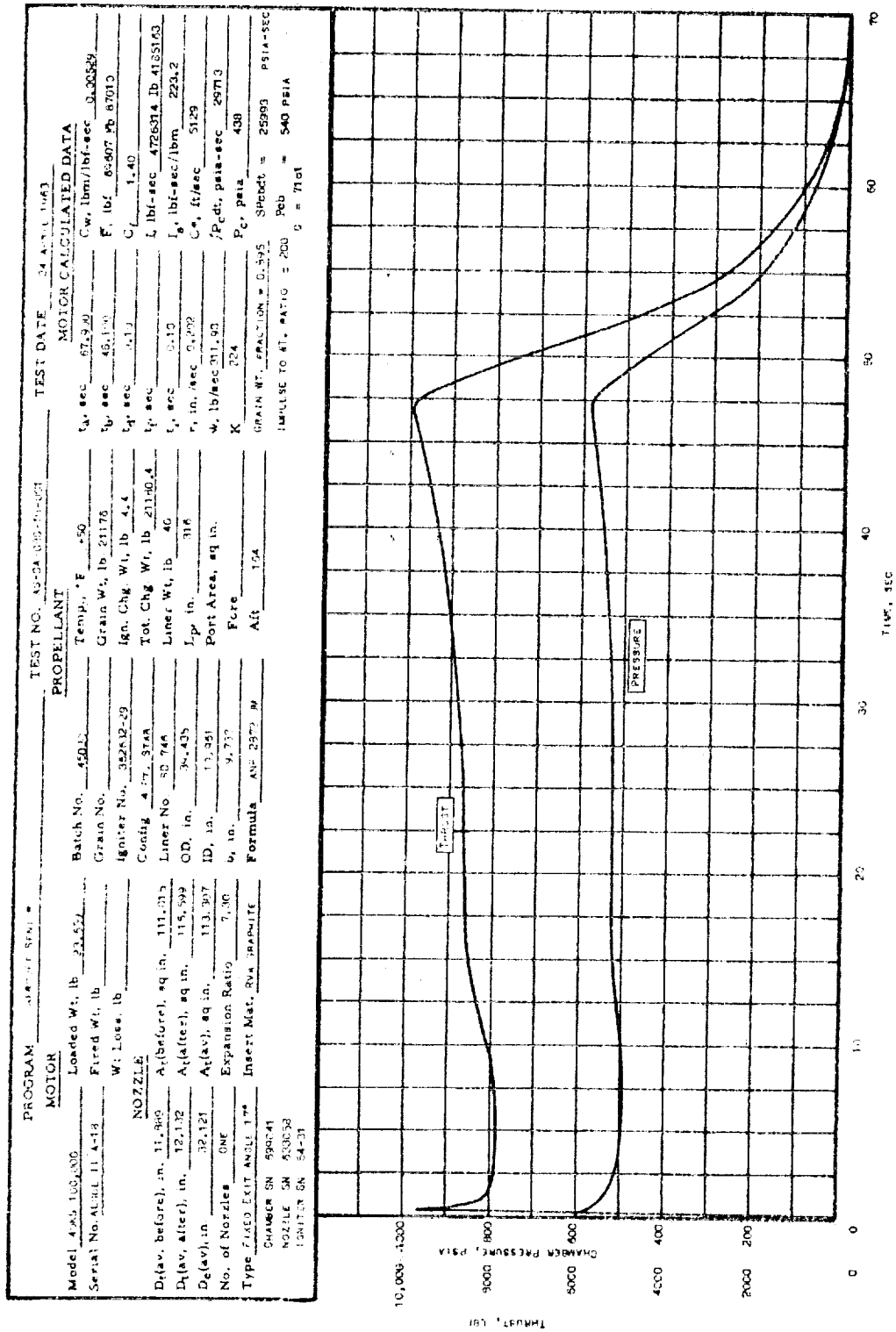


Figure 7



Pressure- and Thrust-vs-Time Curves for Motor IIA-18

Figure 8

General Motor Characteristics

Loaded motor weight, lbm	23,659
Propellant weight, lbm	21,176
Total inert parts weight, lbm	2483
Expendable motor weight, lbm	Not Available
Nozzle weight, lbm	435
Chamber weight, lbm	1641
Insulation weight, lbm	344
Liner weight, lbm	40
Igniter weight, lbm	30
Weight loss, lbm	Not Available
Igniter charge weight, lbm	4.5
Characteristics velocity (C*), ft/sec	5129
C _w (total burning time), lbm/lbf-sec	0.00629
Web thickness, in.	9.737
Nozzle exit cone half angle, degrees	17
Maximum thrust misalignment (calculated), degrees	0.2008
Motor overall length, in.	357.6
Chamber dia., in.	40.0
Operating temperature limits, °F	+70 to +90
Storage temperature limits, °F	+70 to +90
Initial throat area, sq in.	111.015
Final throat area, sq in.	115.599
Throat area increase, %	4.13

Motor IIA-18 Data

General Motor Characteristics (cont)

Initial exit area, sq in.	810.192
Final exit area, sq in.	810.545
Nozzle expansion ratio	7.30
Propellant mass fraction	0.895
Port to throat ratio	1.48
Initial burning surface area, sq in.	24,800
Free volume, cubic in.	41,800
Grain configuration	4 point star

Motor Ballistic Characteristics

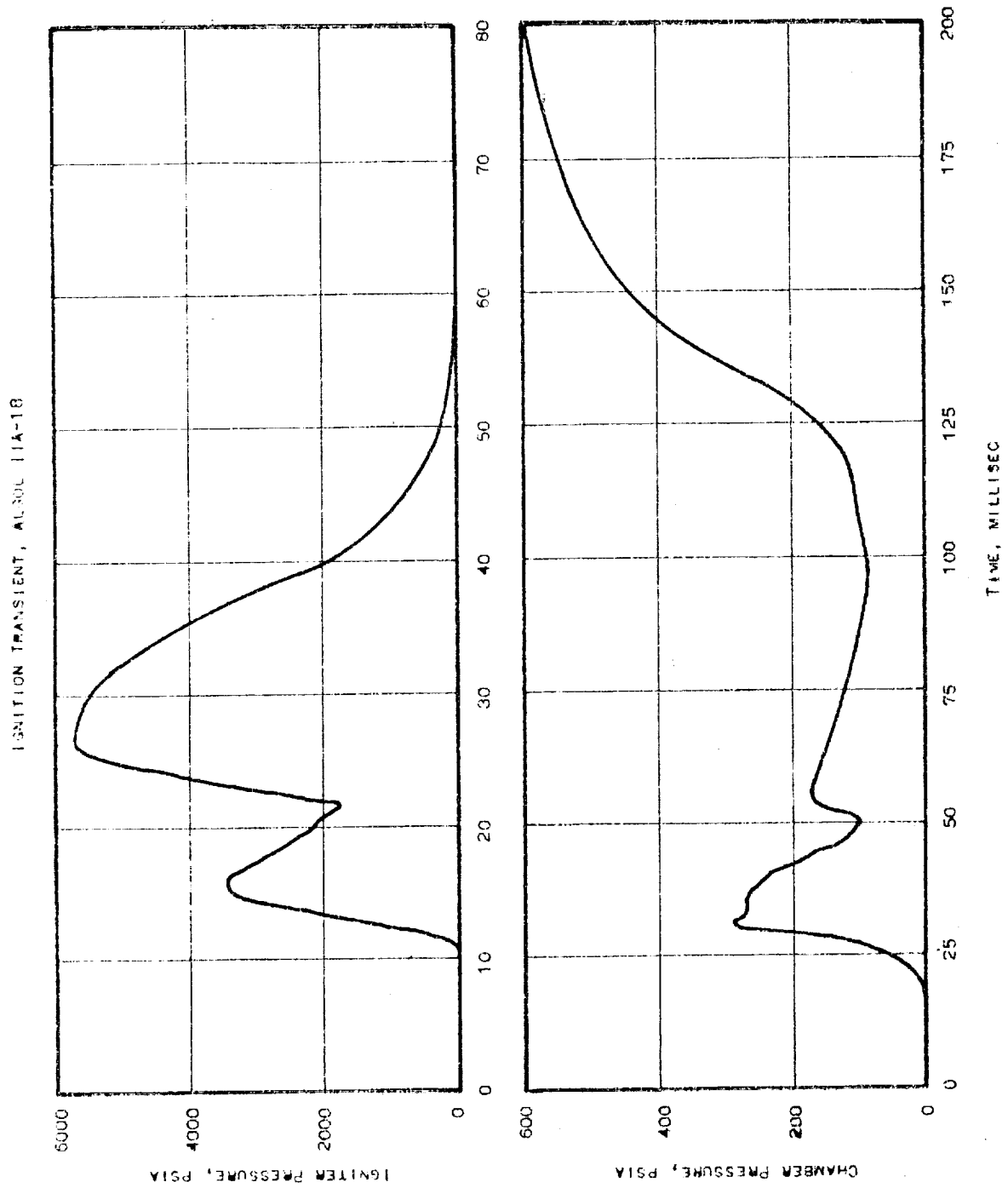
Average thrust (web), lbf	87,010
Average thrust (total), lbf	69,607
Maximum thrust, lbf at 47.277 sec	99,255
Impulse (web), lbf-sec	4,185,163
Impulse (total), lbf-sec	4,726,314
Specific Impulse (total), lbf-sec/lbm	223.2
Average pressure (web), psia	540
Average pressure (total), psia	438
Maximum pressure, psia at 0.234 sec	605.6
Grain temperature, °F	+50
Ignition delay, sec	.100
Ignition interval, sec	.100
Burning rate, in./sec	0.202
Web burning time, sec	48.100
Total burning time, sec	67.900

Motor IIA-18 Data

Motor Ballistic Characteristics (cont)

Weight flow rate, lbm/sec	311.93
C_f (total burning time)	1.40
Impulse to weight ratio, lbf-sec/lbm	200
Center of gravity loaded (measured) inches aft of forward thrust flange	156.89
Center of gravity expended (measured) inches aft of forward thrust flange	Not Available

Motor IIA-18 Data



Ignition Transient Curves for Motor IIA-18

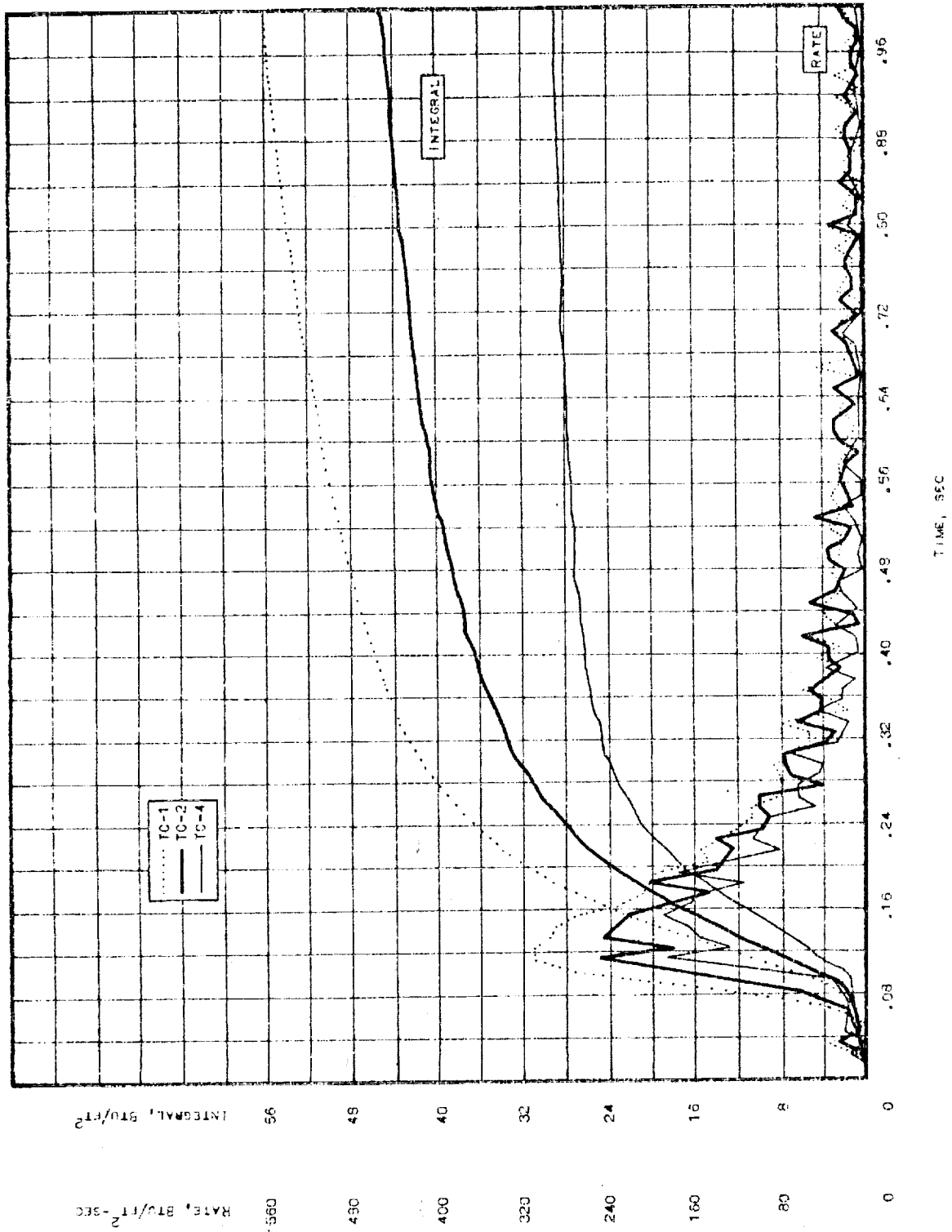
Figure 10

ALCOL HIA IGNITER TEST SUMMARY

IGNITER SERIAL NO.	54-25	54-26	54-27	54-28	54-29	54-30
1. NUMBER OF SQUIBS	2	2	2	2	2	2
2. MAIN CHARGE, GM	1400	1400	2000	2000	2000	2000
3. PELLET TYPE	0-041	0-041	0-041	0-041	0-041	0-041
4. BOOSTER CONFIGURATION	-9	-9	-19	-19	-19	-19
5. AMBIENT PRESSURE	SL	SL	SL	SL	SL	SL
6. MAIN CHAMBER PEAK PRESSURE, PSIG	NOT RECORDED	6850	6000	6935	6840	
7. TIME TO MAIN CHAMBER PEAK PRESSURE, SEC	NOT RECORDED	.031	.033	.027	.030	
8. STATION 1 (7.5 FT)						
A. PRESSURE, PSIA	58	54	107	106	99	108
B. TIME TO PEAK PRESSURE, SEC	.032	.033	.037	.040	.032	.037
C. CALORIMETRY, CAL/CM ²	10.3	15.1	18.7	20.0	19.5	20.6
9. STATION 2 (12.5 FT)						
A. PRESSURE, PSIA	72	70	110	100	102	110
B. TIME TO PEAK PRESSURE, SEC	.036	.036	.039	.041	.034	.039
C. CALORIMETRY, CAL/CM ²	9.7	11.9	17.4	15.7	15.7	19.5
10. STATION 3 (17.5 FT)						
A. PRESSURE, PSIA	76	75	113	103	103	114
B. TIME TO PEAK PRESSURE, SEC	.039	.040	.041	.042	.036	.041
C. CALORIMETRY, CAL/CM ²	-	-	-	-	-	12.8
11. STATION 4 (22.5 FT)						
A. PRESSURE, PSIA	84	80	114	103	105	115
B. TIME TO PEAK PRESSURE, SEC	.044	.049	.042	.043	.038	.044
C. CALORIMETRY, CAL/CM ²	7.5	7.7	14.1	11.9	11.7	13.2

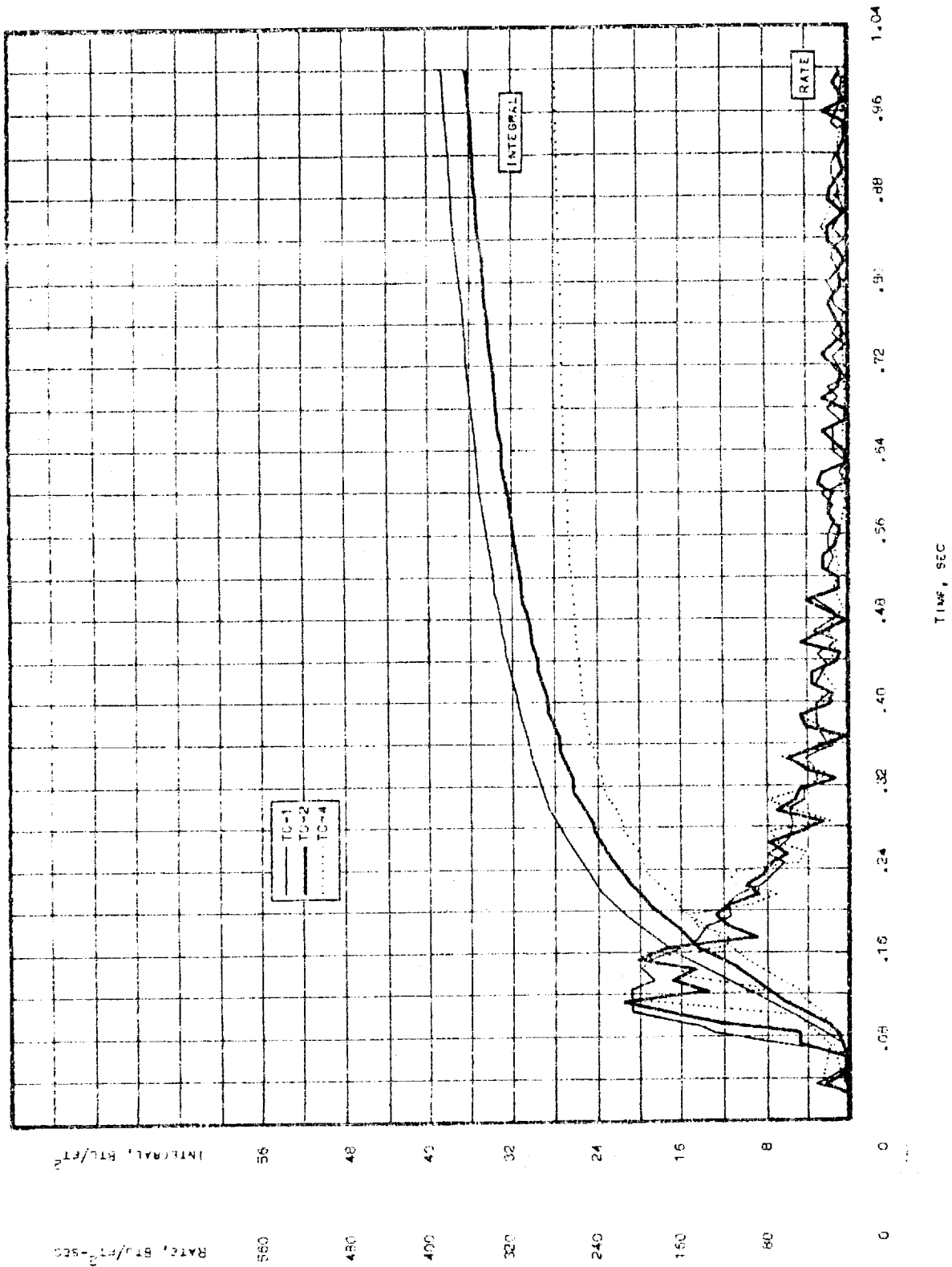
Summary of Igniter Performance

Figure 11



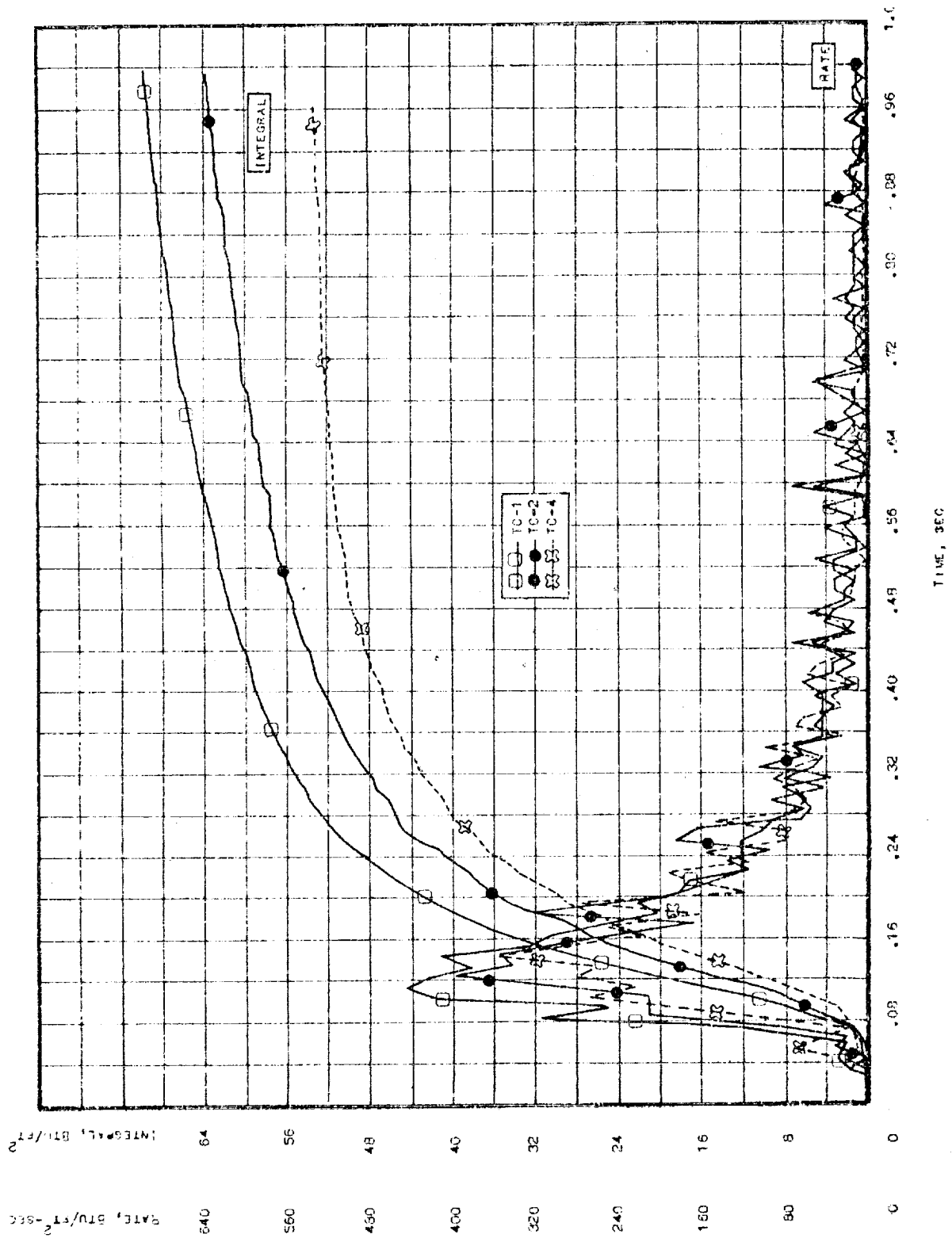
Calorimeter Data for Igniter SN 54-25 (1400-gm Main Charge)

Figure 12



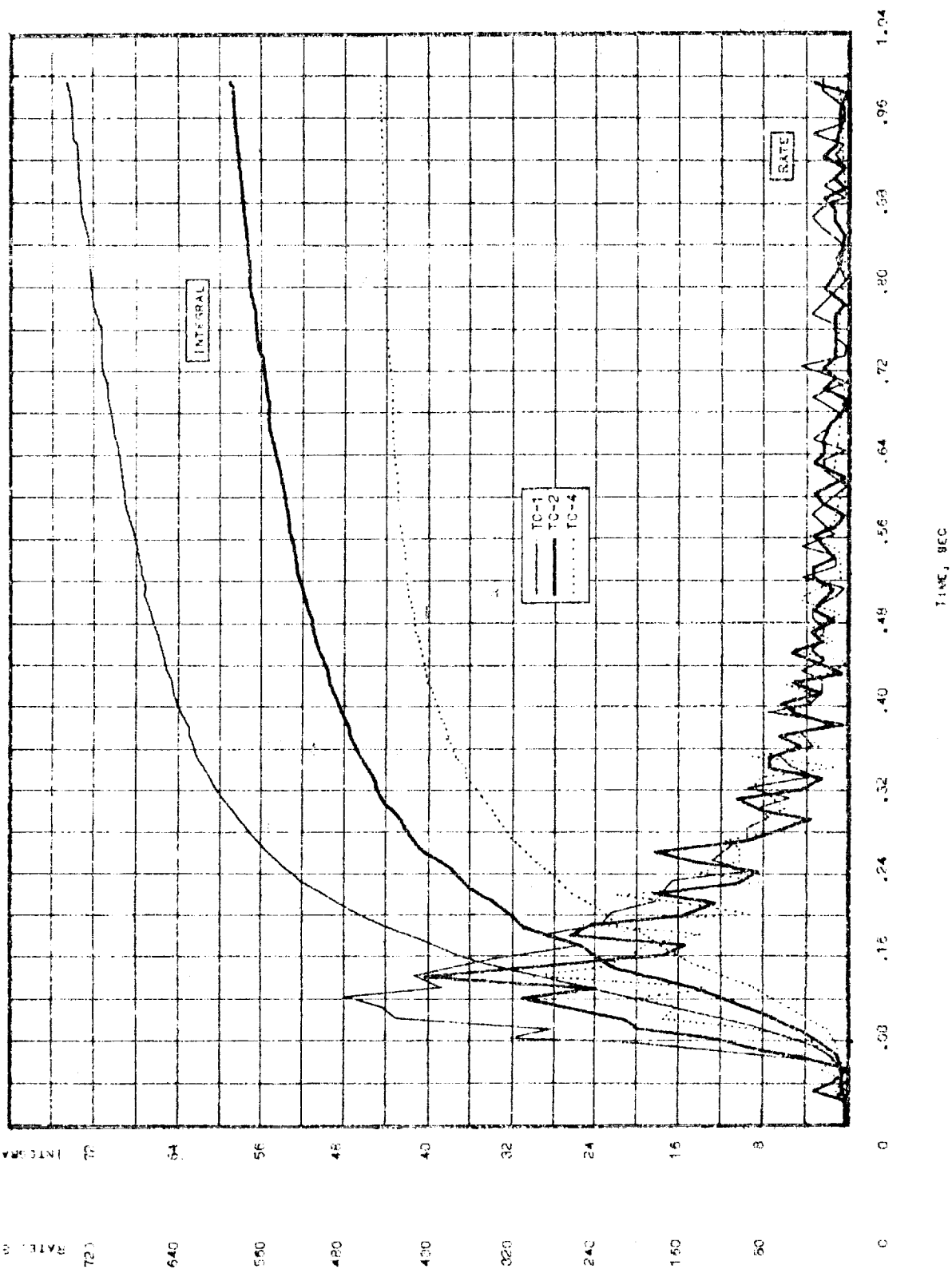
Calorimeter Data for Igniter SN 54-26 (1400-gm Main Charge)

Figure 13



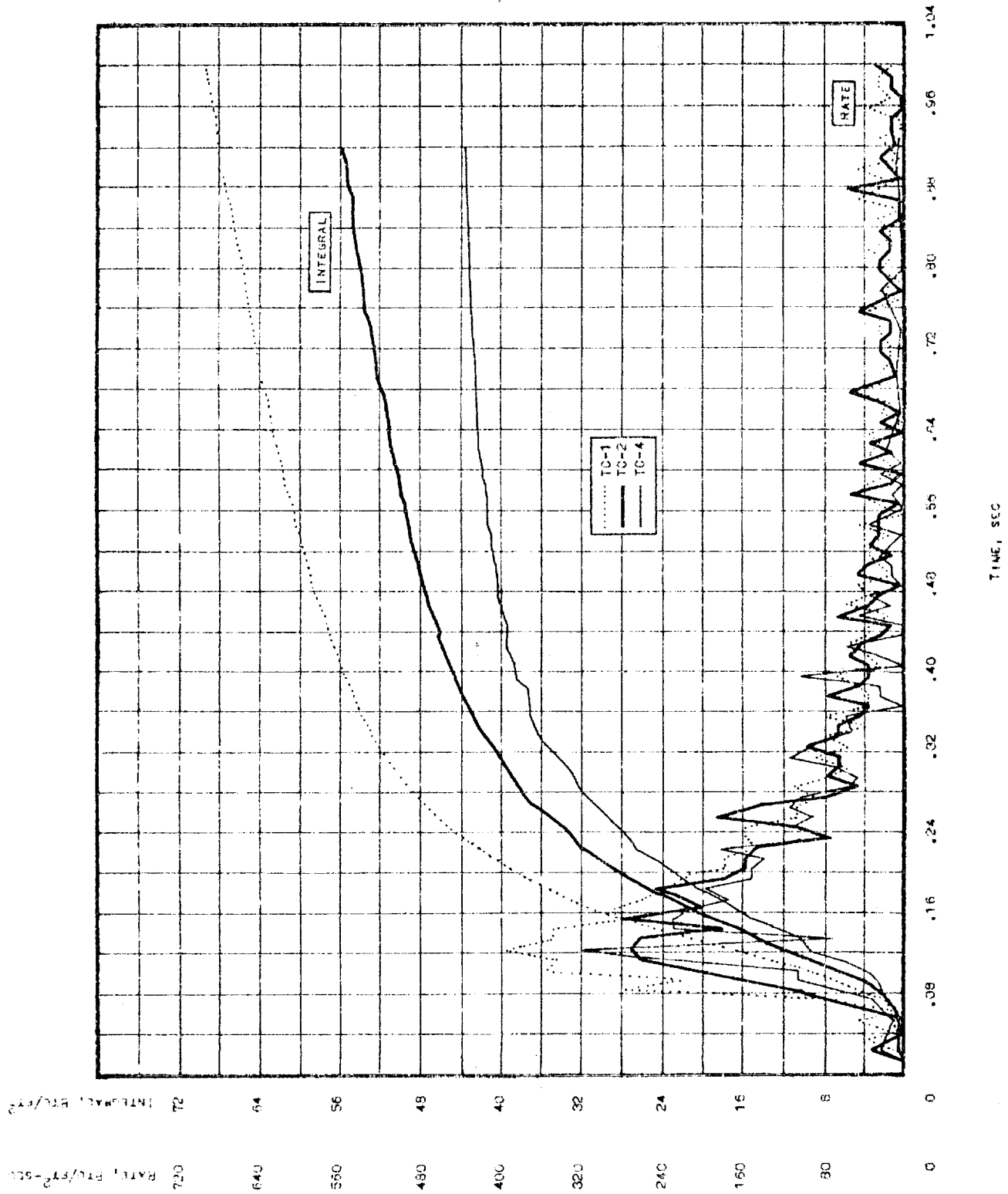
Calorimeter Data for Igniter SN 54-27 (2000-grm Main Charge)

Figure 14



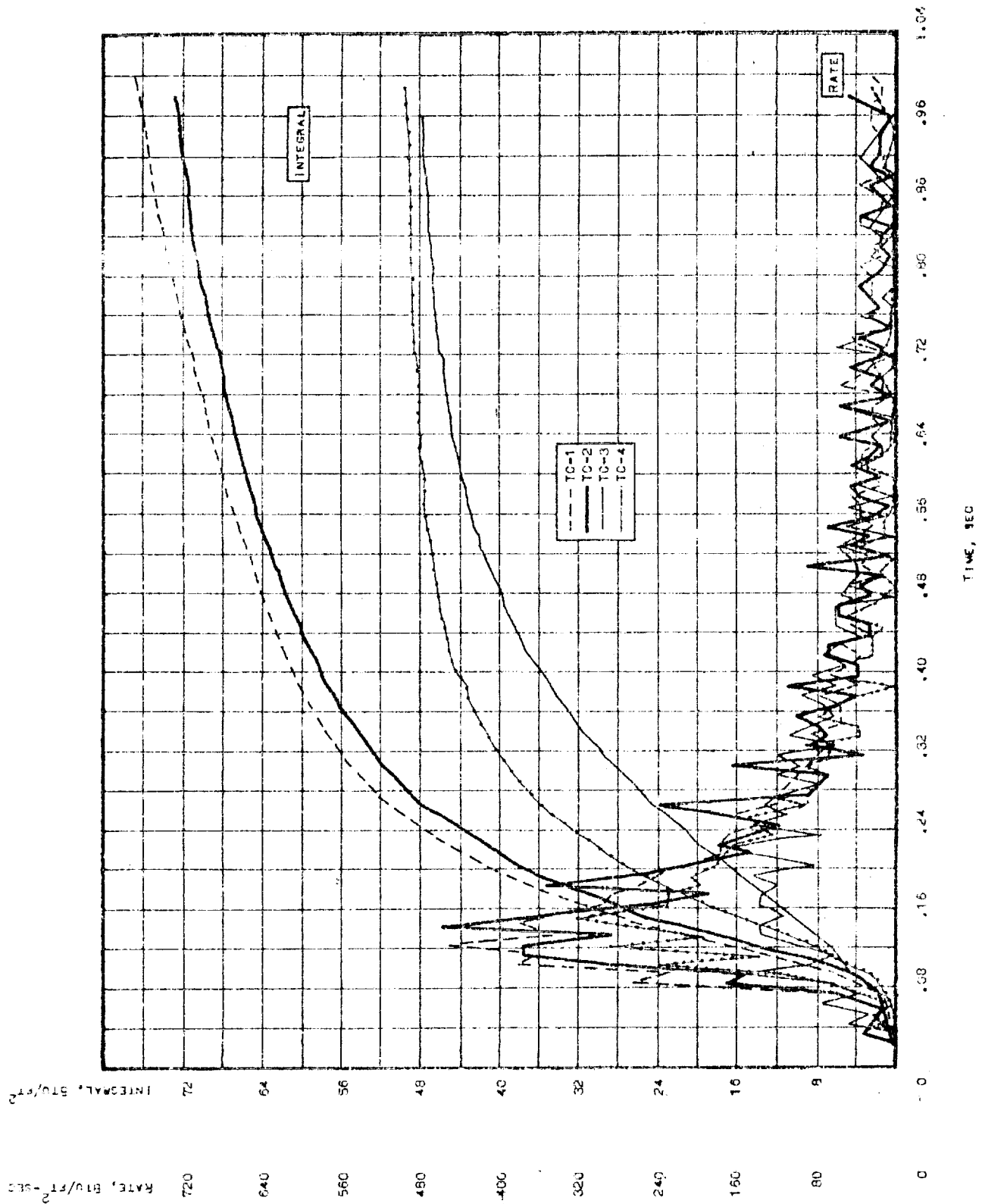
Calorimeter Data for Igniter SN 54-28 (2000-gm Main Charge)

Figure 15

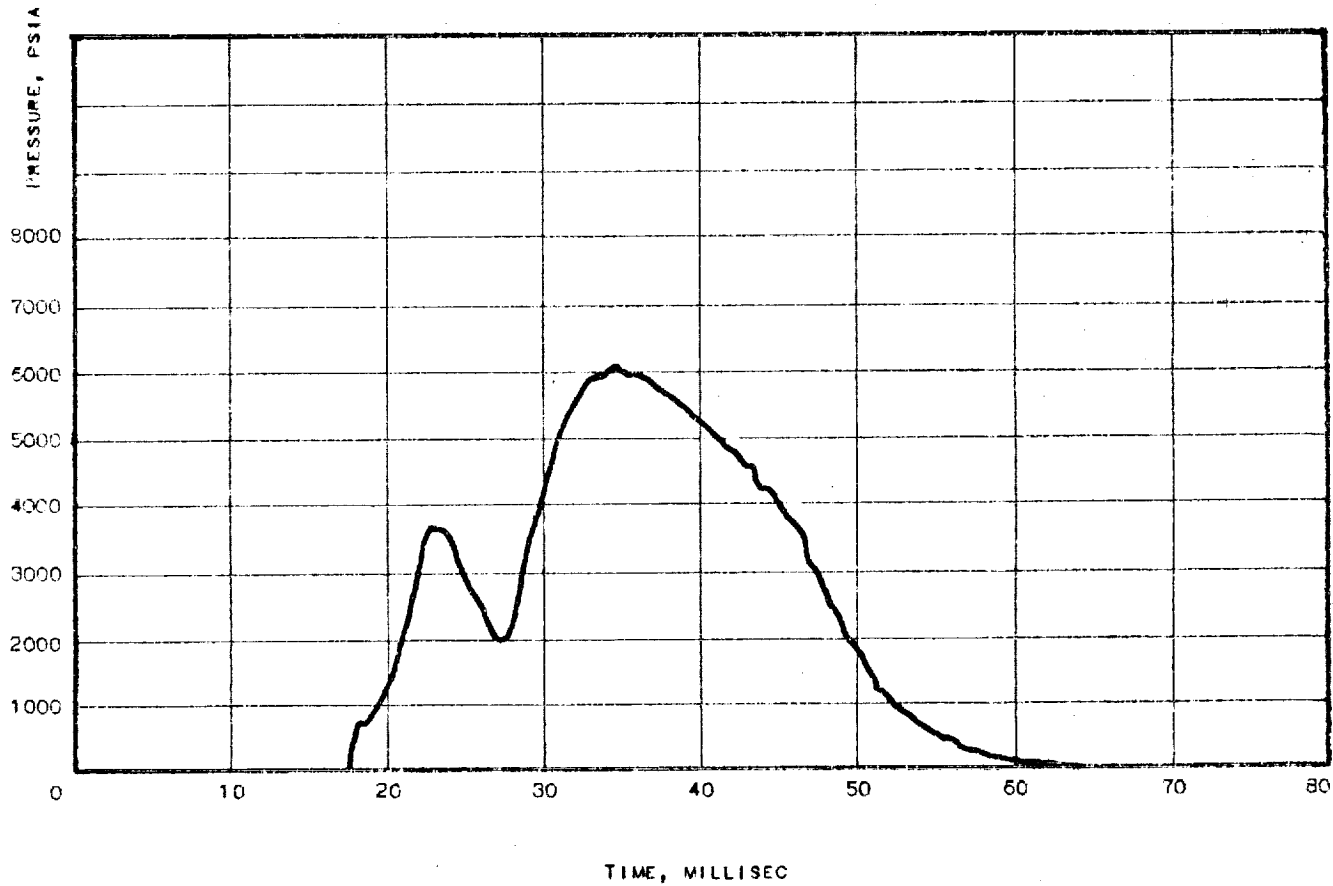


Calorimeter Data for Igniter SN 54-29 (2000-gm Main Charge)

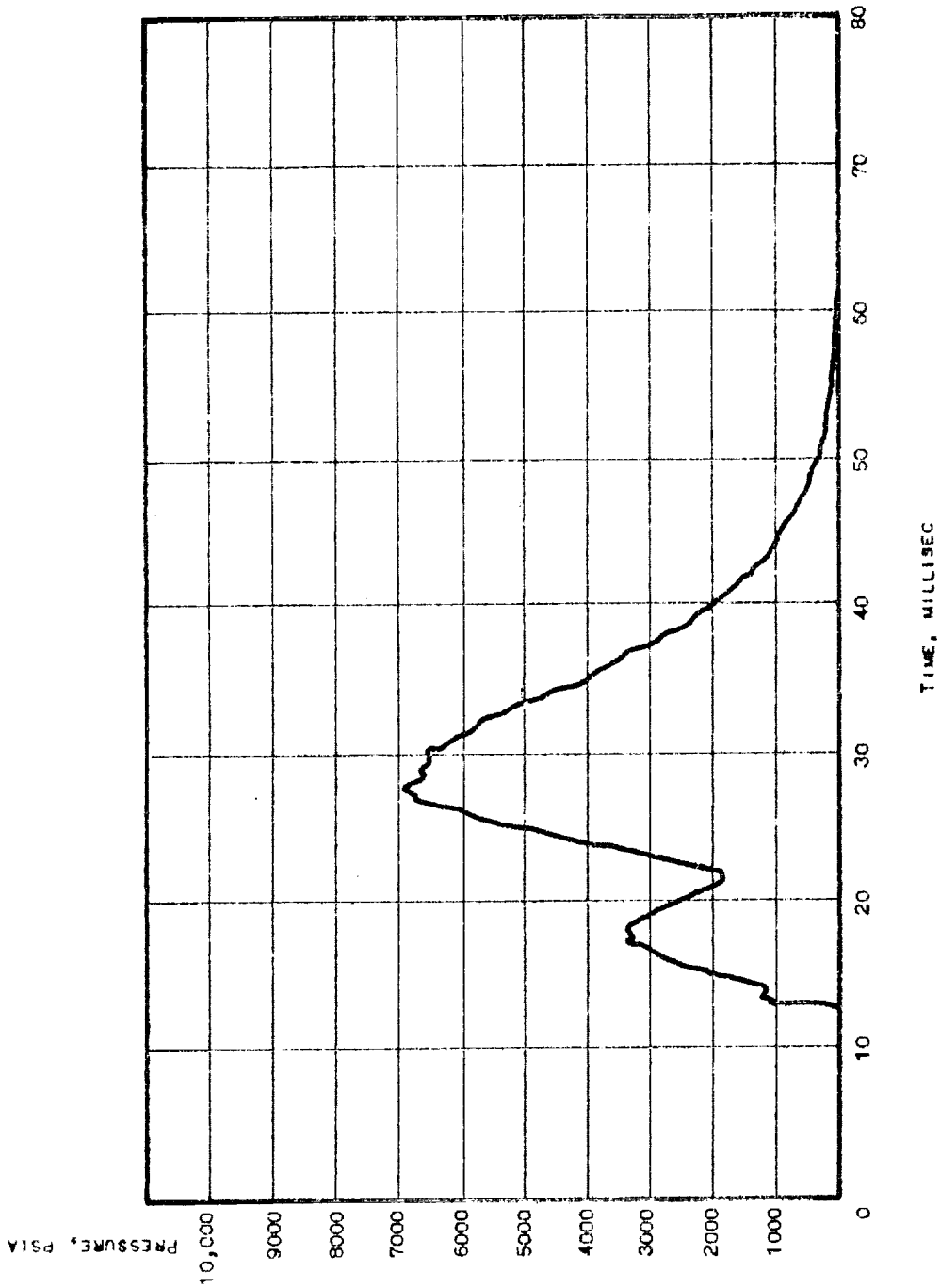
Figure 16



Calorimeter Data for Igniter SN 54-30 (2000-gm Main Charge)



Typical Pressure-vs-Time Curve for 1400-gm Igniter



Typical Pressure-vs-Time Curve for 2000-grn Igniter

Figure 19